UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

UNITED STATES OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

EPA 550-R-97-002
October 1997

EPA/OSHA JOINT CHEMICAL ACCIDENT INVESTIGATION REPORT

Napp Technologies, Inc., Lodi, New Jersey

The EPA/OSHA Accident Investigation Program

Under a Memorandum of Understanding, EPA and OSHA have jointly assumed the responsibilities to conduct chemical accident investigations. The fundamental objective of the EPA/OSHA chemical accident investigation program is to determine and report to the public the facts, conditions, circumstances, and cause or probable cause of any chemical accident that results in a fatality, serious injury, substantial property damage, or serious off-site impact, including a large scale evacuation of the general public. The ultimate goal of the accident investigation is to determine the root cause in order to reduce the likelihood of recurrence, minimize the consequences associated with accidental releases, and to make chemical production, processing, handling, and storage safer. This report is an outgrowth of a joint EPA/OSHA investigation to describe the accident, determine root causes and contributing factors, and identify findings and recommendations.

Basis of Decision to Investigate and for Involvement of EPA

An explosion and fire took place at the Napp Technologies facility at Lodi, New Jersey, on April 21, 1995, resulting in deaths, injuries, public evacuations, and serious damage both on and off site. The accident involved a commercial chemical mixture, a gold precipitating agent identified as ACR 9031 GPA, owned by Technic Inc. (Technic) of Cranston, Rhode Island and comprised of sodium hydrosulfite, aluminum powder, potassium carbonate and benzaldehyde (hereinafter "GPA"). EPA and OSHA undertook an investigation of this accident because of the serious consequences and the characteristics of the substances involved. This investigation was conducted in conjunction with OSHA's enforcement investigation.

At the time of the accident at the Napp facility, Napp was performing a toll blending operation. Under a toll arrangement, a company performs chemical manufacturing, blending, or other operations for other companies. Those other companies may not have the equipment or capacity for these operations or may have other reasons for outsourcing these tasks. One of the purposes of this investigation was to identify hazards specific to the toll manufacturing industry that might lead to chemical accidents, and develop recommendations to prevent accidents and improve safety in the toll manufacturing industry.

Executive Summary/Overview

On April 21, 1995, at approximately 7:45 a.m., a violent explosion and fire occurred at the Napp Technologies, Inc. (Napp) specialty chemical plant in Lodi, New Jersey. Five employees of Napp ultimately died (four employees were fatally injured at the site, the fifth employee died several days later due to injuries related to the event). A majority of the facility was destroyed as a result of the fire, and other businesses near the facility were destroyed or significantly damaged. Approximately 300 residents in the area were evacuated from their homes and a school. Additionally, firefighting efforts generated chemically contaminated water that ran off into the streets and nearby Saddle River.

At the time of the explosion and fire, Napp was conducting a blending operation involving water-reactive chemicals. The chemical mixing portion of the operation, which should have been completed in less than an hour, continued for nearly 24 hours. Operators noticed an unexpected reaction taking place in the blender, producing increasing heat and release of foul-smelling gas over time.

The joint chemical accident investigation team (JCAIT) formed by OSHA and EPA determined that the most likely cause of the accident was the inadvertent introduction of water/heat into water-reactive materials (aluminum powder and sodium hydrosulfite) during the mixing operation. The water caused sodium hydrosulfite in the blender to decompose, generating heat, sulfur dioxide, and additional water. The decomposition process, once started, was self-sustaining. The reaction generated sufficient heat to cause the aluminum powder to rapidly react with the other ingredients and generate more heat. During an emergency operation to off-load the blender of its reacting contents, the material ignited and a deflagration occurred which resulted in the deaths of the Napp employees and destruction of the facility.

The JCAIT identified the following root causes and contributing factors of the event:

• An inadequate process hazards analysis was conducted and appropriate preventive actions were not taken.. Napp's process hazard analysis identified the water reactivity of the substances involved, but was inadequate to identify and address other factors, including sources of water/heat, mitigation measures, recognition of deviations, consequences of failures of controls, and steps necessary to stop a reaction inside the blender. Consequently, appropriate prevention actions were not taken.

• Standard operating procedures and training were less than adequate. Napp's standard operating procedures (SOPs) and related training did not adequately address emergency shutdown, including conditions requiring shutdown and assignment of shutdown responsibility, and operating limits, including the consequences of deviations, abnormal situations, and corrective steps required.

• The decision to re-enter the facility and off-load the blender was based on inadequate information. Although Napp was aware of, and concerned for, the strong possibility of a fire, there was a lack of knowledge or understanding whether off-loading the blender would have made the situation worse or the potential for violent deflagration.

• The equipment selected for the GPA blending process was inappropriate. The blender used by Napp for the process was inappropriate for the materials blended.

• Communications Between Napp and Technic were inadequate. Napp was carrying out a blending operation for another company. Inadequate communication of hazard information between the companies led to an inadequate process hazard review.

• The training of fire brigade members and emergency responders was inadequate. Napp fire brigade members were not trained to respond to the type of emergency that occurred.

1.0 Background

1.1 Facility Information

The Napp Technologies, Inc. (Napp) facility in Lodi, New Jersey, was located on Main Street in a mixed industrial/residential section of Lodi. Napp shared a block with other businesses and was directly across the street from homes and retail businesses (see Figure 24).

Operations

Napp's primary business is pharmaceutical manufacturing. However, in limited cases, it also performs toll blending operations. In a tolling arrangement a company contracts with another company to perform a specific operation. Typically, the company letting the toll contract lacks the equipment or capacity to manufacture the chemical product. The raw material is delivered to the toll manufacturer, who processes it according to customer specifications, and delivers it to the original company for a fee or toll.

At the time of the explosion, Napp was performing a blending operation to produce ACR 9031, a gold precipitating agent (GPA) under a toll blending arrangement with Technic Inc. (Technic) of Cranston RI. Lacking the necessary equipment to blend the ingredients, Technic entered into a contract with Napp whereby Technic purchased the components of GPA and had them delivered to Napp to be blended.

The Patterson-Kelley (PK) 125 blender used in the GPA blending operation was located in the PK-125 Blending Room, located in the Pulverizing and Blending Department on the South side of the facility, near the main warehouse area (see Figure 1).

Facility Chemical Review Procedures

Consistent with Napp's "New Product Review" standard operating procedure (SOP), new products that potentially will be used or manufactured at the Napp Lodi facility are subject to an evaluation of employee health and safety, permit requirements, regulatory compliance (FDA, EPA, NJDEP, etc.), equipment suitability, process limitations and product characteristics. The New Process Review is an internal procedure in which management officials, the Regulatory Affairs Manager, Chemical Manufacturing and Engineering Manager, Operations Director, and Vice President of Regulatory and R&D participate.

The objective of the "New Product Review" procedure was *"to establish a uniform policy for evaluating potential products before their use or manufacture on this site."*

The Regulatory Affairs Manager initially reviews the job request which may be rejected due to regulatory concerns or company policies. If accepted, the Regulatory Affairs Manager will

(Figure 1 can be found in the hard-copy version of this report.)

complete the New Product Review form, assemble relevant documentation, and circulate the package to other Napp management for further review. As part of that management review, the Chemical Manufacturing and Engineering Manager, the Operations Director, and the Vice President of Regulatory Affairs individually review (i.e., no concurrent team review) the package for safety, permitting, and process requirements. The last person to review the package returns it to the Regulatory Affairs

Manager. Each participant in the review indicates his approval or rejection of the proposal on the New Product Review Form. All of the managers involved in the New Product Review approved of the processing of the GPA.

According to Napp's accident report: *"Material Safety Data Sheets and other information provided by Technic formed the primary basis for this review. Instrumental in Napp's acceptance of the project was the Company's review of its prior successful processing of approximately the same volume of these materials in the same blender and the absence of any disclosure from Technic of prior explosions, uncontrolled reactions or other accidents that had previously occurred during the blending of these materials."*

1.2 Process Information

GPA Blending Process

The GPA that Napp was blending is used to recover precious metals, such as gold, from aqueous cyanide solutions. The primary ingredients of the precipitating agent are aluminum powder and a reducing agent, sodium hydrosulfite. The precipitating agent also contains potassium carbonate, an alkali metal, as an activator. The ingredients were mixed in the following approximate proportions, by weight: 66% sodium hydrosulfite, 22% aluminum powder, and 11% potassium carbonate. A small amount (8 liters) of benzaldehyde was also to be added to the mixture for odor control.

To prepare the GPA, according to patent information, the three powdered components are mixed prior to use. The ingredients may be mixed in a simple cone blender or other mixing device. The intended blending time, from the time when all dry powders are charged until the time of unloading, is approximately 45 minutes.

Napp had once previously, in July 1992, blended a batch of ACR 9031 GPA for Technic, Inc., in its PK-125 blender. Before this operation, Napp technical personnel conducted a new product review. No formal record of this review was made, although production records were retained along with the Material Safety Data Sheet (MSDS) for each of the components of the GPA. The 1995 blending ingredients were virtually the same as in 1992. The 1995 blending operation was intended to be the as in 1992; however, because of operation deviations, the 1995 batch operation was significantly different.

(Figure 2 can be found in the hard copy version of this report).

Patterson-Kelley 125 Blender

Figure 2 shows a typical Patterson-Kelley V-shaped blender. Patterson-Kelley builds each blender with options and features as specified by the purchaser. The blender at Napp had a working capacity of 6 cubic meters (125 cubic feet). It was approximately 6 meters wide (19 feet), including supports, and 3 meters (10 feet) high. The blender is a double-lobed stainless steel shell shaped like a heart. It is supported on its widest dimension by a horizontal trunnion attached to support tubes set in cement footings. It is insulated with a rigid foam material and encased in a steel jacket containing a water/glycol mixture for cooling and heating. The two access covers on top of the blender are used for loading raw materials, and one port is located at the bottom for off-loading product. A gear to one side of the blender (right side of Figure 2) rotates the shell of the blender through a 360-degree arc. Several water lines enter the jacket on this side. On the other side (left side of Figure 2) of the blender, a vacuum tube housing enters the blender. A graphite seal located inside the vacuum tube separates the seal's cooling water from the internal area of the vacuum tube and the blender. The purpose of the vacuum tube housing is to: (1) act as a conduit for establishing vacuum conditions when the blender is used for drying and other operations; and (2) contain other concentric lines, shafts, etc., including a liquid feed line (added by Napp) and the shaft used to rotate an intensifier bar (I-bar). The purpose of the I-bar is to enhance the mixing of materials being blended. The purpose of the feed line is to allow the controlled introduction of liquids to the materials being blended. The PK-125 blender can be used with or without the I-bar in service. The I-bar, Figure 3, transverses the inner walls of the blender connecting the inner sides of the blender on the same plane as the trunnion. See Figures 4-8 showing a larger but similar blender and associated equipment.

1.3 Chemical Information

The chemicals involved in the explosion were sodium hydrosulfite, aluminum powder, potassium carbonate, and benzaldehyde. The properties and hazards of these chemicals are discussed below.

Sodium Hydrosulfite

Sodium hydrosulfite (sodium dithionite), $Na_2S_2O_4$, is a whitish, crystalline solid, with moderately strong reducing properties. It is principally used in dying and bleaching operations.

The National Fire Protection Association (NFPA) (NFPA 49, Hazardous Chemical Data, 1994) rates chemical hazards on a scale of 0 (lowest degree of hazard) to 4 (highest degree of hazard). NFPA rates sodium hydrosulfite as 2 for health hazards (moderate) and notes that combustion byproducts may include sulfur dioxide. Sodium hydrosulfite is rated 1 for flammability and described as a combustible solid. NFPA rates it as 2 for reactivity and notes that exposure to moisture from humid air or small amounts of water can result in spontaneous chemical reactions that may generate sufficient heat to initiate thermal decomposition. The U.S. Department of Transportation (DOT) lists sodium hydrosulfite (49 CFR Part 172) in Hazard Class 4.2

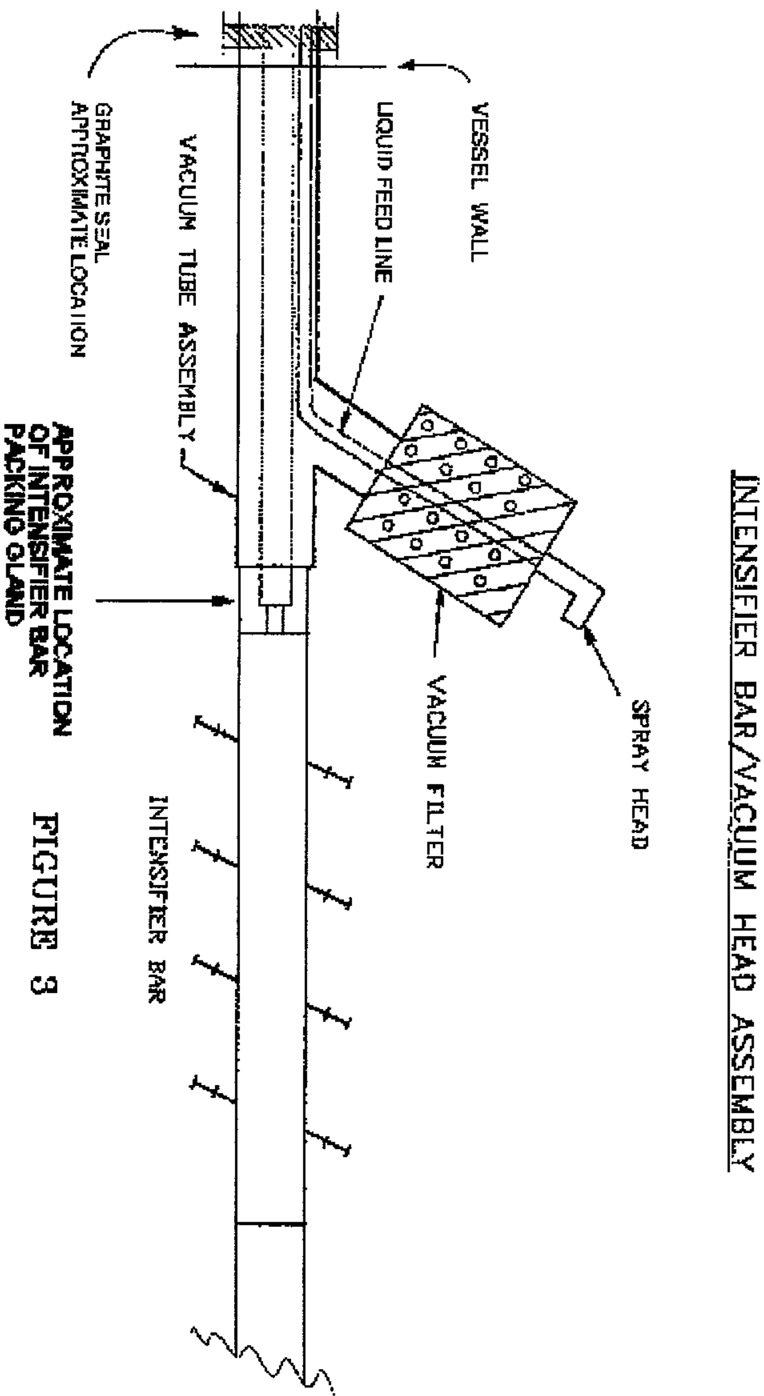

FIGURE 3

(Figure 3 can also be found on the hard-copy of this report.)

(spontaneously combustible material), Packing Group II. Packing Group II is assigned to materials that present a "medium degree of danger." The shipping label "SPONTANEOUSLY COMBUSTIBLE" is required for sodium hydrosulfite.

Sodium hydrosulfite is unstable in the presence of water, heat or humid air, giving off sulfur dioxide gas and other sulfur products in an exothermic reaction. Once initiated, the decomposition process of hydrosulfite supports continued decomposition due to the generation of heat in the exothermic reaction. Therefore, once the decomposition has been initiated, it cannot be extinguished with smothering agents. To quench the decomposition, the temperature of the material must be lowered below the decomposition temperature.

The material safety data sheet (MSDS) for sodium hydrosulfite supplied by Technic notes in the event a container feels hot or begins to smoke it should be removed to an open area and "*flood with water.*"

The decomposition temperature of sodium hydrosulfite is identified on the MSDS as 130 C. Under Reactivity Data, the material is described as "stable" although moisture and heat in excess of 50 C are identified as conditions to avoid.

Aluminum Powder

Aluminum powder is light grey or silvery colored. Air dispersions (dust clouds) of aluminum particles, when mixed in proper proportions and exposed to a small amount of ignition energy, will burn with such rapidity that if contained an explosion may occur Aluminum powder has a number of uses related to its flammability and explosivity when dispersed in air, including use in explosives, propellants, and pyrotechnics. As a component of explosives, aluminum powder is used to increase explosive power.

NFPA (NFPA 49, 1994) rates aluminum powder as 0 for health hazards, indicating health hazards are minor. Under "Fire and Explosive Hazards," NFPA 49 describes aluminum powder as a "[f]lammable solid if finely divided. Forms explosive mixtures in a dust cloud in air. Bulk dust when damp with water may heat spontaneously. Hazard greater as fineness increases." The rating for flammability hazard is 3, the rating that applies to liquids and solids that can be ignited under almost all ambient temperatures. Aluminum powder has a rating of 1 for reactivity hazards. DOT lists aluminum powder, uncoated, on its Hazardous Materials Table in Hazard Class 4.3 (dangerous when wet material), Packing Group II ("medium" degree of danger). The shipping label "DANGEROUS WHEN WET" is required for uncoated aluminum powder.

Sax's "Dangerous Properties of Industrial Materials" fifth edition, (page 352) indicates that aluminum powder is a moderate explosion hazard when finely divided as dust and dispersed with gaseous SO_2, under appropriate conditions.

Water will react with aluminum dust to produce hydrogen gas, especially under alkaline conditions. Aluminum is normally protected by an oxide coating, but the coating is readily dissolved by alkaline agents such as bicarbonate. Once the oxide coating is removed, the aluminum becomes very reactive. The oxide coating normally reforms rapidly and exothermically on contact with air. The uncoated condition is ideal for aluminum to become pyrophoric, i.e., burst into fire spontaneously under appropriate conditions.

The MSDS for aluminum powder, uncoated (atomized), as written by Valimet, Inc., and supplied by Technic to Napp states:

Under Section IV: Fire and Explosive Data:

"Special Fire Fighting Procedures: Avoid water"

Under Section VI: Reactivity Data:

"Incompatibility (Materials to Avoid): Water, acids, alkalis.

Hazardous Decomposition Products: Exothermic reaction with water, acids, alkalis to generate hydrogen and heat."

Benzaldehyde

Benzaldehyde is a colorless liquid. Benzaldehyde readily oxidizes to benzoic acid. To prevent contact with air, an inert gas blanket over the material is required.

Benzoic acid is a white crystalline material. When benzoic acid is heated above its melting point, some formation of benzoic anhydride and water takes place. When heated above 370C, it decomposes to benzene and carbon dioxide, with small amount decomposing to phenol and carbon monoxide.

Potassium Carbonate

Potassium carbonate is usually in the form of white crystalline granules. Because of its alkaline chemical nature, it is commonly used to raise the pH of mixtures and solutions. Potassium carbonate has some acute health hazards (irritant to all body tissue, possibly leading to tissue destruction), giving it an NFPA health hazard rating of 2. NFPA fire and reactivity ratings for the material are 0, indicating that it is a stable compound.

Gold Precipitating Agent

The MSDS for the gold precipitating agent supplied by Technic, Inc. notes:

"Flammability Data: Contact with small amounts of water or humid atmosphere will cause a chemical reaction. The heat generated from this reaction is sufficient enough to ignite combustible material . . . Flood the material with water to ensure complete wetting, as this procedure will control the auto-ignition of the material.

Extinguishing Media: Water spray should be used to extinguish fire

Usual Fire Fighting Procedures: Use water to keep fire exposed containers cool."

Unusual fire fighting techniques are asserted not to be applicable. Hazardous decomposition products specified are limited to oxides of sulfur, carbon dioxide and carbon monoxide. Incompatibles identified by Technic are limited to "oxidizing agents or materials, strong acids and moisture.

2.0 Description of the Accident

2.1 Events Preceding the Blending Operation

In January of 1995, Technic contacted Napp to inquire about the timing of an order of GPA. In February 1995, Napp informed Technic that the next available date to make GPA would be March 23, 1995. In preparation for that job, Napp decided to perform a new product review. The Regulatory Affairs Manager, Chemical Manufacturing and Engineering Manager, Operations Director, and the Vice President for Regulatory and R&D participated in the review which included the evaluation of the processing information available from 1992, the MSDS prepared by Technic for its GPA, the MSDSs of the components of the mix, as well as other information. They noted the water-reactive nature of the components of the GPA.

In March of 1995, in preparation for the blending of one batch of GPA, Technic began procurement of the various raw materials and made arrangements for their shipment to Napp. A slight delay in the scheduled blending of the GPA pushed the production date into April. On April 7, Technic sent Napp a purchase order, a duplicate of the GPA MSDS already in Napp's possession, and a sign-off by Technic's Director of Operations on the formulation sheet (batch recipe ticket) indicating that it was "OK to blend." The delivery of materials to Lodi commenced in March and was completed with the delivery of aluminum powder on or about April 4, 1995. The components of the blend included 1,800 pounds of powdered aluminum, 900 pounds of potassium carbonate, 5,400 pounds of sodium hydrosulfite, and eight liters of benzaldehyde. The blended GPA was to be packaged into 18 plastic-lined 55-gallon drums, supplied by Technic.

2.2 Preparations for Blending

Preparations for the processing to be performed commenced on Monday, April 17, 1995 when the PK-125 blender was rinsed with deionized water. Thereafter, the rinsewater was discharged. The intensifier bar was removed from the vessel, dismantled by mechanics, and cleaned.

The maintenance foreman instructed a maintenance employee to remove and change the packing gland associated with the intensifier bar on the PK-125 blender. This activity was standard procedure whenever there was a scheduled product change for one of the Napp P-K blenders. After removing the old packing gland and its housing, the maintenance employee observed water next to a bearing. Based on this observation, the maintenance foreman instructed the maintenance employee to drain the water out of the area, replace the packing, and seal the blender. As part of the procedure to check the integrity of the seal and packing gland, the maintenance employee ran the blender and its intensifier bar for 15 minutes and visually inspected the interior of the blender to assure that the water-cooled seal and packing gland were not leaking. The mechanic found no evidence of leakage.

The blender was given a final rinse, and the rinsate was checked for the presence of contamination. Quality Control personnel "released" the blender and the room in which it was housed to Operations personnel and the cleaning log was signed signifying completion of the cleaning process, approving both for use in preparing the next product, the GPA.

On April 19, prior to charging the materials, the first shift supervisor conducted a process review with operators on duty. It was a Standard Operating Procedure that any operator engaged in materials processing must complete a detailed review with the shift supervisor of the process and its hazards prior to commencing work. The review, which typically takes 45 minutes to an hour, was done for each operator involved in the Technic process, and included a discussion and review of the equipment set-up, the steps to be undertaken in the process, and a complete review of the MSDSs for GPA and each component of the mixture. The shift supervisor and two operators found a minor water leak from a water pipe in the back of the PK-125 room (not associated with the blender). The shift supervisor stopped the leak, dried up any water that remained, and covered the floor drains in the room to prevent contact of GPA with water in the sewer system in the event of a spill. A sign informing workers that water reactive chemicals were being processed in the PK-125 room was placed at the entry to the room.

At approximately 10:30 p.m. on April 19, the shift supervisor conducted a process review with the night shift crew. Exhibit 1 shows the timeline of events beginning at this point.

The process review with the operators concluded at approximately 11:15 p.m. The operators and leadmen then pre-weighed the GPA components, placing the unopened drums of sodium hydrosulfite and aluminum powder and bags of potassium carbonate on a digital scale and recorded the weight of the material and its container on a log. In the course of this activity, it was discovered that one of the bags of potassium carbonate had been broken and taped over and it weighed less than the others. To assure proper proportions for the GPA, a calculation was performed and the volume of the other raw materials was adjusted for the batch to be mixed.

At 3:30 a.m. on April 20, as part of the precharging verification, operators made a final check to assure the blender was ready (i.e., clean and dry) to be loaded. The two operators and a foreman discovered that the vacuum head area, inside the blender, was wet. They also observed water on the internal walls of the blender. Another employee saw a wet spot also described as "droplets of water on the stainless steel" at the intensifier bar shaft seal (connection). They believed this moisture was

(Exhibit 1 can be found in the hard-copy version of the report.)

caused by condensation.

Knowing that water reactive materials were to be loaded into the blender, the night shift foreman directed an operator to wipe off the portions where moisture was found. The blender was then heated using the water-glycol jacket on the PK-125 to further dry the interior surfaces. The blender was allowed to cool and was checked to ensure it was ready to be charged with the raw materials and found to be dry.

2.3 Blending Operation

Prior to the commencement of loading operations, the operators implemented a standard operating procedure that required that a vacuum twice be created within the blender and then broken with inert nitrogen gas. Thereafter, a slight nitrogen pressure was maintained to assure inert conditions within the blender. At approximately 5:00 a.m. on April 20, operators began to load the components of the GPA into the blender, but did not finish the work. At 6:00 a.m., a shift change occurred, and the first-shift day crew arrived to continue blending operations.

A process review of the GPA blend had been conducted for the new operators, and the hazardous nature of the raw materials was discussed. At approximately 8:00 a.m., the first shift operators recommenced loading of the blender alternating proportionately from one component to the next as had the previous operators. Because loading occurred only through one port of the "V"-shaped blender, and to distribute the materials evenly across the blender, the intensifier bar was rotated briefly. The loading of the blender concluded at approximately 11:00 to 11:30 a.m. Thursday morning. During the final charging, the blender was rotated to level (settle) the powders to allow all of the material to be loaded. An operator noted that the charge was not dusty when the blender was opened for the final addition. After charging was complete, the level of the powdered components completely covered the intensifier bar and was almost up to the middle of the vacuum head. Thereafter, the operators commenced the blending operation according to Napp's procedure, which called for blending the dry powders as follows: rotate the blender for ten minutes without the intensifier bar; five minutes with the intensifier bar; and ten minutes again without the intensifier bar. The dry blending was completed by mid-day.

The operators then made preparations to spray charge the benzaldehyde, a procedure requiring the use of a separate liquid feed tank connected by hoses to a spray nozzle atop the vacuum head within the blender. Operators noted a "vanilla-like" odor from a liquid feed tank for the blender, and water was observed inside the tank. Additionally, the operators found water in an internal filter located on the liquid feed line near the point of entry into the blender. However, because the components of the GPA, with the exception of the benzaldehyde, were already in the blender, the portion of the feed spray line located inside the blender could not be cleaned without contaminating the materials in the blender. The operators did not consider the liquid feed line to be functioning properly. The liquid spray head and spray system had not been completely dried prior to the charging of the blender. The operators placed a gallon of isopropyl alcohol (IPA) into the liquid feed tank and blew inert nitrogen through the tanks and lines into a bucket forcing the IPA through the system, with the exception of that portion of the line entering the blender and terminating at the spray nozzle. They then blew nitrogen through the liquid feed system for 45 minutes to one hour to make certain the feed tank and lines were dry.

At approximately 2:30 p.m., the operators attempted to charge the benzaldehyde into the blender. In doing so, the operators placed the benzaldehyde in the liquid feed tank, charged the tank with nitrogen pressure, commenced rotation of the blender and intensifier bar, and relieved the pressure into the blender. The operators noted the feed rate was unusually low, and upon inspection, they noticed that most of the benzaldehyde had ended up in a vacuum line separator bowl and not in the blender (Figure 3A). Upon consideration of the failure of the liquid feed system to correctly spray the benzaldehyde into the blender, it was determined to examine the compression fitting to the liquid feed line to see if it was leaking.

An operator noted that the liquid in the bowl had a few drops of water or IPA on top of the benzaldehyde. No further analysis was performed on the liquid.

At 7:00 p.m. an employee entered the PK-125 room and smelled an odor described as "rotten eggs." The employee observed 18 drums which previously contained the raw materials. These drums sat uncovered. Assuming the residue inside the drums was the cause of the odor, he put the tops back on the drums.

At 7:30 p.m., a maintenance employee was instructed to troubleshoot the liquid feed system line. When the employee attempted to open the vacuum line to gain access to the feed line the employee was splashed with a "stinky" liquid. The maintenance employee received minor chemical burns and went to the locker room to wash off the chemical.

Between 7:30 and 10:00 p.m., one hatchway on the PK-125 blender remained open to the atmosphere. During this period the operators continued to run a nitrogen purge through the vacuum line into the blender so as to maintain an inert blanket in the head space of the blender.

At approximately 10:00 p.m., another maintenance employee completed the disassembly of the exterior portion of the vacuum line and took it to another room, where it was washed and dried. When the employee returned to the PK-125 room the employee smelled an odor that he described as a "dead animal" smell upon initially entering the PK-125 room. This employee also observed and smelled the liquid from the separator bowl which had been collected in a beaker. The employee described the smell as "awful." The maintenance employee cleaned up the liquid which had earlier spilled on the floor. By this time, it had been almost ten hours since the ingredients were placed into the blender (the blending should have taken not more than one hour to complete).

At 10:00 p.m., the maintenance employee informed the shift supervisor about the unusual odors in the PK-125 room. The maintenance employee finished reinstalling the vacuum line to the blender, and the shift supervisor went to the lab to obtain more benzaldehyde to inject into the blend.

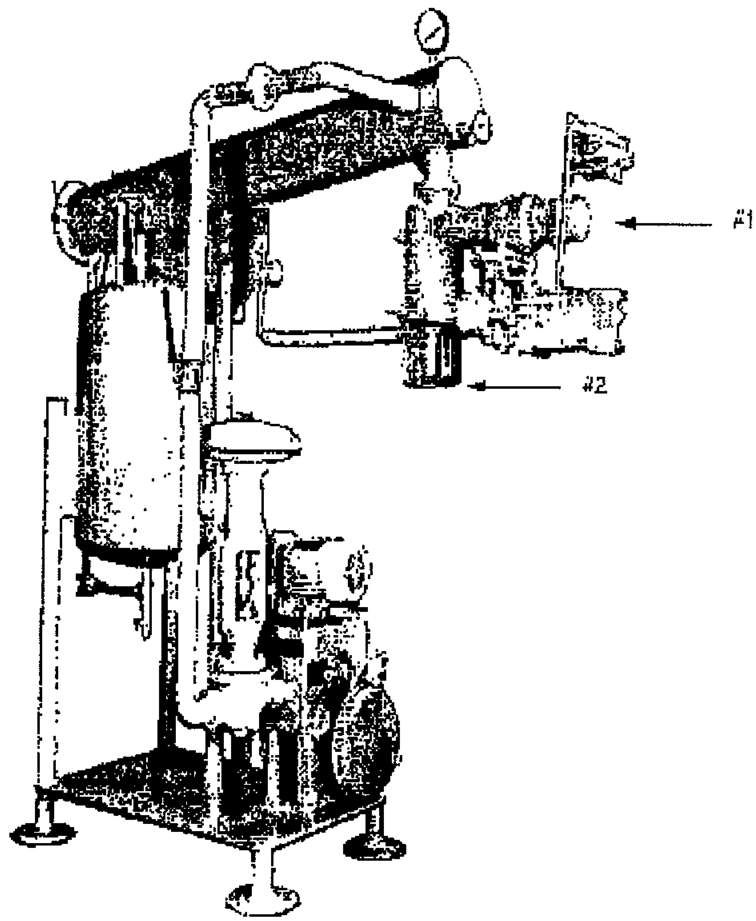

Figure 3A: Typical Vacuum Collection System as Supplied by Patterson-Kelley. #1 shows approximate location of inlet from blender vacuum line; #2 shows vacuum separator bowl.

(Figure 3A can also be found in the hard-copy version of this report.)

Between midnight and 4:30 a.m. on April 21, 1995, the third shift attempted to inject benzaldehyde into the batch on two occasions; each attempt failed. Operators observed the benzaldehyde running back into the vacuum separator. During each attempt to add the liquid, the blender was rotated for about two minutes with the intensifier bar running. Suspecting that product was blocking the spray tip of the nozzle and preventing the injection of the liquid, operators opened the blender twice and removed and washed the spray nozzle. Operators reportedly observed a slight dusty powder wafting within the head space of the blender. This was reported to the shift supervisor, who then checked the inside of the blender and directed the operators to remove and clean the nozzle. After the final attempt to charge benzaldehyde into the vessel it was determined that no fresh benzaldehyde remained. It was by then approximately 5:00 a.m. and coming to the end of the third shift. The shift supervisor told the operators to perform a lock and tagout of the blender.

The shift supervisor noted that a pressure gauge on the blender was reading five pounds per square inch (psi). Inasmuch as the blend was to take place under atmospheric conditions, in a blender designed for non-pressurized service, concern arose that the rise in pressure could result in the two charging ports being blown out of the blender. Because there was a continuous flow of nitrogen into the blender, the pressure gauge was replaced with an open nipple, and the pressure was released into the PK-125 room. The nitrogen purge rate was then increased.

The shift supervisor reportedly observed an area of about 8 inches in diameter bubbling and smoking on the surface of the material inside the blender.

2.4 The Explosion and Fire

As employees arrived at the plant for the morning shift on April 21, they noticed a rotten egg odor. At approximately 5:30 a.m. the operators of the blender had observed puffs of white smoke coming from the exhaust nipple affixed to the PK-125. By 6:00 a.m. employees on the first shift had reported to their assembly areas. Nearly all Napp employees smelled the odor of rotten eggs, which by then had escaped the building and was noticeable in the parking lot behind the plant. At approximately 6:15 a.m. the plant was evacuated, through verbal instructions; no audible alarms were ever activated at the facility.

At about the same time, there was a discussion about whether the GPA should be unloaded from the blender. At approximately 6:30 a.m., the third shift supervisor placed a call to the Vice President for Regulatory Affairs (VPRA) and advised him of the situation. After asking a series of questions for more information, in a subsequent phone conversation at approximately 6:45 a.m., the VPRA directed the shift Supervisor to discharge the batch "ASAP." The VPRA suggested tumbling the blender with cooling medium (glycol) circulating in the water jacket. The shift supervisor stated that he did not want to rotate the blender because that would require capping the exhaust nipple that had been installed to relieve the pressure buildup inside the blender. The VPRA directed the shift supervisor to maintain the nitrogen purge into the blender. Additional phone calls were also made from the plant to other Napp management personnel.

During discussions regarding unloading of the blender and upon review of the GPA MSDS, it was suggested that a fire hose would be strung out to the PK-125 room but not charged in order to prevent accidental discharge of water. Later, an additional hose was made available.

At approximately 7:00 a.m., the third shift supervisor went outside and approached the plant employees who had been evacuated to the rear parking lot. Several employees, including the first shift supervisor, returned to the blending room with him to assist with the unloading of the blender. Other employees, who were members of the Napp Fire Brigade, reentered the plant to stand by with fire hoses at the ready, but were instructed by the Production Manager not to charge them with water unless they were told to do so by another employee who would be closely watching the unloading operation. The maintenance supervisor stood in a doorway that led from the blending room to a hallway from which he could see both the unloading activities and the fire brigade member standing by awaiting a signal to charge the fire hose.

At approximately 7:47 a.m., three loud hissing noises were heard in succession. The noises were closely followed by a "whoosh" sound, then the explosion. The blender and its two 10-ton concrete footings were propelled in a westerly direction for a distance of approximately fifty feet. An employee standing by stated that he heard hissing noises, looked inside the blending room, and saw the other workers in animated activity. He turned to run, saw two bright flashes of what reminded him of lightning, and saw a yellow-orange ball of flame "like a snake's tongue" leap out of the room toward him. He was blown along the length of the corridor and out a passage door; he survived with minor injuries.

Four of the five employees in the PK-125 blending room were killed in the explosion and ensuing fire, and the fifth employee died of burns a week later. Four other employees escaped with minor injuries.

2.5 Emergency Response

At the sound of the explosion, Lodi police, fire, and EMS responded to the scene within minutes. Information concerning the chemicals stored at the facility was promptly made available to responders. Nine persons injured in the explosion were transported to a local hospital. Approximately 300 residents in the vicinity were evacuated from their homes, as well as a nearby elementary school.

Other responding agencies included EPA, OSHA, United States Coast Guard, Federal Bureau of Investigation, NJ Department of Environmental Protection (NJDEP), NJ State Police Office of Emergency Management, Bergen and Passaic County Health Departments, Bergen County Prosecutor's Office and the Arson Squad. Hundreds of volunteer fire and ambulance personnel also responded, as did more than 20 other municipal police.

Continuous air monitoring was conducted by seven NJDEP teams for the duration of the fire. monitoring was conducted by NJDEP, Bergen and Passaic County Health Departments.

Observable during the firefighting response was a discharge of the chemical fluorescein, a bright green dye, which was stored at the Napp facility. Fluorescein-contaminated firefighting runoff water entered the Saddle River through the storm drains and by direct overland flow. Fluorescein-contaminated runoff also entered the sanitary sewer line feeding the sewage treatment plant. The Passaic Valley Sewage Commission was notified of the release. Napp Technologies hired a cleanup contractor to contain firefighting runoff. Evidence of firefighting runoff was seen in the Saddle River in the form of a bright green discoloration for two miles downstream to its confluence with the Passaic River.

A USEPA mobile laboratory vehicle was used to acquire downwind air samples of inorganic/acid gases, organic, and ketones. In addition, water samples were obtained at seven locations for off-site analysis. Water samples were analyzed for volatile organic compounds, base-neutral-acids, metals, pesticides, and PCBs.

Fish kills were confined to the Saddle River, for approximately 2 miles downstream to the confluence with the Passaic River. No fish kills were observed in the Passaic River. The residential evacuation order for Lodi and the surrounding communities was lifted on April 22 at 8:30 p.m.

2.6 Napp Fire Brigade Members and Emergency Responders

Among the Napp employees involved in the attempt to remove the GPA from the blender were several who were members of the Napp fire brigade and had been trained in incipient fire fighting techniques.

Napp fire brigade members and other Napp emergency responders were directed by management to respond to the ongoing chemical emergency. Nine of the twelve employees who were inside the building immediately preceding the explosion (during the unloading of the GPA) were also members of the Napp fire brigade. Training records revealed that some employees were given a lecture on chemical fires, but no formal training was conducted related to fighting chemical fires or emergencies. A course on hazardous materials was presented to the fire brigade in November 1993, but the records note that none of five listed managers, including three of the deceased employees, attended the session. The same training records indicate that four of the five managers failed to attend six fire brigade training sessions in 1993 (the fifth manager attended one session), and the same individuals failed to attend similar training courses, including one on hazardous materials and one on emergency response in 1994. In 1995 the same individuals missed three fire brigade training sessions, including one on fire behavior given 10 days prior to the explosion. The Napp Plant Safety Standard for Fire Protection Organization specifically defines the function of the Plant Fire Brigade as, among other things, to "answer all fire calls." It also states that the "intent of the Brigade is to fight incipient stage fires only." It further states that "The Brigade will perform a contain and hold function on any major interior structural fire until the Lodi Fire Department arrives."

Link to Next Section: Analysis, Significant Facts and Causes of the Accident.

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Last Updated: October 24, 1997